

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of:)	
)	ET Docket No. 02-135
Spectrum Policy Task Force Seeks)	
Public Comment on Issues Related to)	
Commission's Spectrum Policies)	

REPLY COMMENTS OF COGNIO, INC.

William Seed
Thomas Scholl
COGNIO, INC.
Suite 350
101 Orchard Ridge Drive
Gaithersburg, MD 20878
(240) 631-1910

Nicholas Allard
James H. Barker
Bart S. Epstein
LATHAM & WATKINS
Suite 1000
555 Eleventh Street
Washington, DC 20004
(202) 637-2200

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Cognio, Inc. ("Cognio") is pleased to submit reply comments in this Spectrum Task Force proceeding.¹ As a technology company focused on developing products to advance the proliferation and quality of short-range wireless communications in the unlicensed bands, Cognio supports the Commission's continuing efforts to stimulate advanced communications technologies. Cognio has reviewed the initial comments filed and sees several important ideas worth Commission attention and action.

1. INTRODUCTION

The explosive growth in wireless applications and devices over the past few years has produced tremendous public interest benefits. Wireless networks and devices have been deployed in millions of offices, homes, and more recently, in increasing numbers of public areas. These wireless deployments are forecast to continue at an exciting pace and offer the promise of increased convenience and productivity.

¹ Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies, ET Docket No. 02-135, Public Notice, FCC DA 02-1311, dated June 6, 2002.

This growth, which is taking place mostly in the unlicensed bands, is not without its downsides. As many commenters have noticed, as unlicensed devices become more popular and their density in a given area increases, a “tragedy of the commons” effect will often become apparent, and overall wireless utility (and user satisfaction) will collapse. This phenomenon has already been observed in environments that have a high density of wireless devices.

Historically, the wireless industry’s general approach to solving “tragedy of the commons” problems has been for manufacturers to simply move to another commons further up the spectrum. This solution, however, is not workable for much longer, due to spectrum scarcity and to the less attractive technical characteristics of the higher bands (decreased signal propagation and the inability to penetrate surfaces).

Recognizing the scarcity of spectrum and the escalating use of the unlicensed bands, Cognio recommends that the Commission provide regulatory incentives that encourage more efficient and intelligent use of the unlicensed bands. As a specific step to encourage innovation, Cognio recommends that the Commission consider designating a small portion of the unlicensed spectrum for devices that use smart, adaptive, cognitive or otherwise intelligent power and/or spectrum management techniques.

2. THE COMMISSION SHOULD ENCOURAGE THE ADOPTION OF TECHNOLOGIES THAT MORE INTELLIGENTLY USE AND SHARE THE UNLICENSED BAND

To improve the overall use of the unlicensed bands for an expanding set of devices and applications, Cognio recommends that the Commission adopt regulations that provide incentives for technologies to use the unlicensed bands intelligently and efficiently. As a simple technical matter, cognitive devices offer increased spectral efficiency and therefore increase the overall communications carrying capacity of the unlicensed bands. While it is true that many manufacturers will choose to incorporate intelligent spectrum management technology into their

future devices, others, because of the simplicity of their applications, will undoubtedly choose to continue to produce spectrum inefficient “dumb” devices that use spectrum wastefully.

To draw the analogy to the original “tragedy of the commons”² notion of a common pasture, if fifty farmers using “dumb” grazing techniques can share a common pasture, and the government either encourages or requires those farmers to employ “intelligent” grazing policies that double their efficiency at virtually no additional cost, those farmers can now each graze twice as many cattle in the common pasture without depleting pasture’s resources. (Or, the original fifty farmers could each graze 50% more cattle and an additional twenty five farmers using intelligent grazing policies could share the pasture as well.) The role of the government in reaching an optimal situation is simple – create incentives or requirements for farmers to adopt intelligent grazing techniques and discourage or prohibit farmers from unnecessarily using “dumb” grazing techniques.³

In the world of spectrum usage, the Commission is faced with a similar situation. There is widespread agreement that the use of “intelligent” devices will increase the amount of spectrum available to all users. The comments filed demonstrate widespread agreement that the Commission should act to encourage devices that include cognitive radio features because they can dramatically improve band sharing, reduce harmful interference and improve all users’ experiences. For example:

- BellSouth suggests that unlicensed devices should use mechanisms that automatically select frequencies and minimum power;⁴
- Motorola discusses the importance of “cognitive radio” systems for enhancing public benefit;⁵ and

² Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243, 1244-45 (1968).

³ What the government wants desperately to avoid is the situation where half of the farmers agree to employ intelligent grazing policies and the remaining farmers simply expand their use of dumb policies.

⁴ *Comments of BellSouth Corporation* at 6, ET Docket No. 02-135, July 8, 2002.

⁵ *Comments of Motorola, Inc.* at 20, ET Docket No. 02-135, July 8, 2002 (“*Motorola Comments*”).

- Cisco Systems discusses the benefits of advanced spectrum-sharing technologies.⁶
- A. THE COMMISSION SHOULD REQUIRE DEVICES OPERATING IN THE UNLICENSED BANDS TO INCLUDE COGNITIVE RADIO FEATURES**

Cognio believes that the Commission should require new devices using the unlicensed bands to adopt technologies that better facilitate band sharing and coexistence between a multitude of devices that use disparate technologies. The Commission need not endorse any particular standard, methodology, or technology. Instead, it can and should simply require that future devices contain varying degrees of cognitive radio capability that enable devices to sense their local radio environment and/or detect the presence (and application needs) of other devices that are accessing the same unlicensed band. The capability of sensing, detecting and classifying other unlicensed users in a device's vicinity is an important requirement in being able to determine how a device can most effectively use the spectrum. This cognitive radio philosophy applies to both individual devices and to networks of devices.

As with licensed wireless applications, predictability of performance is important to the satisfactory delivery of unlicensed band wireless services. The successful provision of cognitive spectrum management techniques has the potential to help unlicensed band applications evolve from today's view of wireless as convenient though often secondary, to one in which unlicensed band connections are viewed as reliable, primary, and robust.

Unlike wired and licensed band wireless connections in which access to the media is controlled and effectively managed, the unlicensed bands are available for use by disparate wireless technologies. The consequences for a device operating in such an environment in terms of performance can be catastrophic. For example, two commercially successful unlicensed standards, IEEE 802.11b and Bluetooth, behave "unintelligently" when operating in the vicinity of each other.

⁶ *Comments of Cisco Systems, Inc.* at 6, ET Docket No. 02-135, July 8, 2002.

Experiments in Cognio's laboratory have confirmed that when exposed to the interference of a Bluetooth frequency-hopping signal, an IEEE 802.11b device detects an "increase in its error rate" and responds by decreasing its over-the-air transmission rate. Decreasing its transmission rate does not necessarily help and when the IEEE 802.11b device continues to detect an unacceptably high (or potentially higher) error rate, it further reduces its data rate. This action is compliant with the IEEE 802.11 standard, and yet is patently unintelligent. The device effectively increases its exposure to a frequency hopper by increasing the duration of its packet through the reduction in over-the-air data rate. While it is true that standards bodies may improve coexistence between open standard protocols in these types of situations, this type of degradation in performance could be minimized or even avoided completely, by the deployment of cognitive spectrum management technologies.

Through intelligent use of the unlicensed bands, overall capacity can be increased and satisfy the needs of more users. Frequency re-use in which the same band is used in multiple geographical areas has been shown to dramatically increase the capacity. Reducing a "frequency cell" size as currently demonstrated by licensed band operators allows higher overall throughput at the expense of additional equipment. Power level limitations in the unlicensed bands makes frequency re-use a virtual necessity in the provision of wireless services over areas beyond a few hundred square meters. By adopting intelligent power control mechanisms, frequency re-use in the unlicensed bands can be further extended.

For so-called Personal Area Network (PAN) applications, in which the range of wireless connectivity is limited to a few meters, the level of interference created by such PAN devices may be made to be very low by controlling the output power to the lowest possible level to sustain its wireless connection. For those cases in which devices are able to sense that no other devices in its vicinity are competing for the wireless medium, it could transmit at as high a data rate as possible,

using as much spectrum as needed, without degrading performance to other nearby devices. Upon detecting the presence of other devices accessing the spectrum, the device could subsequently reduce its bandwidth usage to minimize interference to other devices. Such flexible and intelligent use of the unlicensed band can be an example of a cognitive radio.

The ability of devices to recognize and react to the occupancy of its local RF environment through measurement, detection and classification opens up the opportunity to substantially increase wireless capacity by enabling short-range wireless devices as secondary access users on unoccupied licensed bands, which is similar to a recommendation made in an earlier comment.⁷ Through spectrum management, this access can be provided without impacting the services provided on these licensed bands. This approach has already been adopted in Europe at 5 GHz whereby wireless local area networks (WLAN) have been granted secondary user access to licensed radar bands. The Commission should require such intelligent features to be part of future Part 15 devices.⁸

B. THE COMMISSION SHOULD PROVIDE ACCESS INCENTIVES FOR DEVICES THAT OPERATE WITH HIGHER SPECTRAL EFFICIENCY

There is widespread agreement that the Commission's unlicensed band regulations have fostered experimentation and technological advancement.⁹ Recognizing the success of unlicensed band applications and the unrelenting demand for higher data rate connectivity, Cognio recommends that the Commission evolve its regulations to promote the use of more spectrally efficient technologies, a recommendation also provided by Qualcomm. By providing regulatory

⁷ *Comments of Maurice Robberson.* at 1, ET Docket No. 02-135 (calling for "Smart Radio Technology" to be implemented on a secondary basis in UHF channels 14-69, between 471 MHz and 749 MHz.).

⁸ Cognio supports the idea of building radio regulations into devices. *See generally Comments of Kevin Werbach.* at 1, 5, and 8, ET Docket No. 02-135, July 8, 2002 (calling for an "Intelligent Radio Bill of Rights" and for rules "defining the privileges and responsibilities of smart devices communicating over the airwaves").

⁹ *See generally Motorola Comments.*

incentives, the Commission can help to further stimulate technology advancements and increase the availability and utility of the unlicensed bands for more American businesses and consumers.

The desire to provide reliable, higher data rate wireless connections at greater ranges has led to the evolution of techniques and technologies of varying complexity, cost and performance improvement. In the unlicensed bands, an approach widely adopted by industry in enhancing the range of operation for WLAN devices is that of switched diversity antenna combining. The benefit of an increased range of operation comes at a cost burden of an additional antenna, switching circuitry and firmware which controls the antenna switching, as well as increased complexity within the device. By deploying technology that can intelligently switch between antennas, a lower transmit power can be used than would otherwise be used for a single-antenna device. Thus, this relatively simple technique of switched diversity leads to more users being able to access the same spectrum by reducing required transmit power levels, and thereby enabling more effective frequency reuse. Alternatively, the switched diversity technique enables higher data rates to be sustained at a given range than otherwise possible with a single antenna implementation. For example, at a given range an IEEE 802.11a device which includes 2-antenna switched diversity may operate at the maximum data rate of 54 Mbps while the same device with a single antenna may be limited to 24 Mbps.

Other antenna technologies that improve frequency re-use and data rate at range have been evaluated and deployed with varying degrees of performance improvement and commercial success. For example, sectorized antennas in which multiple co-located antennas provide non-overlapping coverage to increase the range and capacity within a sector than otherwise possible, is widely deployed in licensed band networks, and is under evaluation for unlicensed band applications. In general, antenna technologies deployed today for increasing range and capacity within the

unlicensed bands use multiple antennas and a single transceiver per channel with varying complexity in terms of signal combining.

Technologies exist today that can substantially increase the range of operation of many unlicensed band applications. In addition to the benefit of range extension, a device may communicate at its highest possible level at greater distances. The effect of increased data rate at greater distances enables reduced transmit power levels, reduced levels of interference, and higher data rates at any given range than otherwise achievable. These benefits lead to better support of a high density of wireless devices by providing greater capacity and number of devices that may share the unlicensed bands. Limiting transmit power and the area over which the wireless signal may interfere with other devices and applications is an important element in more effective use of the unlicensed bands.

While it is important to encourage the deployment of technologies that improve the data rate at range equation, it is Cognio's view that higher spectral efficiency is an important component in satisfying the demands for unlicensed band capacity. Technologies exist that can increase the spectral efficiency within a fixed bandwidth well beyond that achievable with today's wireless devices. The demands of higher data rate wireless applications will be better met from all users' perspective by the deployment of technologies that improve upon the spectral efficiency, typically measured in bps/Hz, offered by today's shipping products. Fortunately, the same technologies that enable substantially improved range performance form the basis for dramatically expanding spectral efficiency. By way of an example, IEEE 802.11a is a leading technology today in terms of spectral efficiency, providing approximately 3 bps/Hz. The Commission should encourage the deployment of technologies that substantially increase capacity within a fixed bandwidth and with comparable transmit power. Such technologies are achievable today with modest increases in complexity and

cost, and satisfy the larger goal of allowing more devices, higher data rates and higher reliability within the unlicensed bands.

3. THE COMMISSION SHOULD ALLOCATE “UNLICENSED COOPERATIVE BANDS” FROM EXISTING OR NEW SPECTRUM

Recognizing the reliability and performance advantages associated with licensed spectrum, and the innovation and time-to-market advantages associated with the unlicensed bands, Cognio recommends that the Commission allocate an “unlicensed cooperative band” from existing or new spectrum. Such an allocation would encourage the development and deployment of advanced radio etiquettes, enable spectrum managed multiple access, and ultimately enable devices to more intelligently share spectrum. A device must be “band aware” to understand how much of the band it may use and how best to share the spectrum with other unlicensed cooperative band devices. The provision of such an unlicensed cooperative band could be a important catalyst to the deployment of unlicensed band services such as video, audio and corporate data which need reliable quality of service, and pave the way for a new wave of wireless innovations and applications.

Current regulations limit a device’s transmit level, but do not require it to recognize its local unlicensed band environment. Through advanced spectrum management techniques, wireless devices that can recognize and react to other devices that may use different wireless communications technologies, can be more effectively managed and enable more reliable wireless deployment, benefiting all users of the bands. For those cases of low device density or low spectrum utilization, a device could seize the entire available spectrum for short intervals of time and transmit at extremely high data rates. As the radio environment changes and becomes more “crowded,” the device could free up spectrum and negotiate spectrum occupation with other users of the bands.

4. CONCLUSION

Part 15 has allowed a great many devices to develop and proliferate. In some ways, the only thing Part 15 has to fear is its own unexpected success. It is time for the Commission to take the next logical step and enact regulations and incentives that encourage manufacturers to deploy more efficient, lower interference, higher reliability and more spectrum friendly devices. Best of all, the Commission should set aside some of the unlicensed spectrum for devices that employ cognitive or other adaptive technologies. Doing so will ensure that all American businesses and consumers can continue to benefit from the creativity of the American entrepreneurs who continue to develop innovative tools that enable us all to enjoy the precious public resource the Commission is trusted to protect.

Respectfully submitted,

COGNIO, INC.

By: /s/ Bart S. Epstein

Nicholas Allard
James H. Barker
Bart S. Epstein
LATHAM & WATKINS
Suite 1000
555 Eleventh Street
Washington, DC 20004
(202) 637-2200

William Seed
Thomas Scholl
COGNIO, INC.
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(240) 631-1910

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